REMARKS

Applicants' invention provides a method which enables the patterned etching of a silicon nitride layer using a patterned photoresist as a masking material, when that photoresist is a DUV photoresist. Applicants explain in the "Background" section of their invention that "To obtain smaller feature sizes (than those used in the past), in the range of about 1500 Å, it is presently necessary to use a Deep UV (DUV) photoresist as the patterned masking material for the etching of SiN_x. This requires a reduction in the thickness of the photoresist layer, since DUV photoresist thickness is typically limited to less than about 7000Å for optical reasons. The reduced thickness in the DUV photoresist layer makes etch selectivity of the SiN_x in preference to the photoresist more critical." (Specification, Page 3, lines 14 - 19.) Applicants further explain that: "In addition, when the feature size is reduced from about 2500 Å to about 1500Å, the etch rate for the SiN_x typically decreases because of diffusion limitations pertaining to the removal of etch reaction by-products from the smaller openings to the smaller features." (Specification, Page 3, lines 24 - 26.) Finally, applicants explain that: "To be able to use a DUV photoresist, it is necessary to be able to maintain an adequate selectivity to prevent punch through of the thin photoresist and to be able to obtain an acceptable etch rate for SiN_x". (Specification, Page 4, lines 6 - 8.) Applicants have clearly laid out the problem to be solved: How can the selectivity for etching SiN_x relative to etching a DUV photoresist be increased so that the thin, DUV photoresist can be used as a patterning mask for etching SiN_x?

Claim Rejections Under 35 USC § 103

Claims 1 - 28 and 57 - 67 are rejected under 35 USC § 103(a), as being unpatentable over U.S. Patent No. 5,721,090, to Okamoto et al. ("the Okamoto reference"), in view of U.S. Patent No. 5,910,392, to Nozaki et al. ("the Nozaki reference").

Applicants respectfully contend that a combination of the Okamoto et al. reference with the Nozaki et al. reference does not render applicants' invention obvious.

The Okamoto et al. reference describes the etching of a number of different materials. The only description of the etching of silicon nitride is at Col. 6, lines 13 - 67, continuing at Col. 7, lines 1 - 60. In this description the photoresist thickness was apparently about 10000Å thick, indicating that the kind of problem encountered by applicants was not considered. Further, the plasma source gas mixture was C_4F_8 and O_2, although there is some mention of N_2 gas in a manner where the meaning is not clear.

The Nozaki et al. reference relates to a photoresist composition that can use short wavelength light, such as that from an excimer laser for the imaging radiation. This reference describes specific chemical compositions which can be used to form the photoresist. The reference describes the use of imaging wavelengths which would be considered to be DUV. However, applicants' attorney found no mention of the etching of a silicon nitride film in this reference.

One skilled in the art would have no reason to combine these references from all of the references related to the etching of various materials. However, even if these references were combined, there is nothing in a combination of these references which would suggest a method of improving etch selectivity of silicon nitride relative to a patterned DUV photoresist used as a mask during plasma etching of the silicon nitride, where the etchant plasma is generated from a plasma source gas consisting essentially of at least one inorganic fluorine-comprising gas and sulfur dioxide or a combination of these materials in combination with an inert diluent, as claimed in applicants' independent Claims 1, 15, 57 and 59, from which the other rejected claims depend.

In more detail, the Okamoto et al. reference does not appear to name any particular photoresist which was used to carry out the preferred embodiments and does not specifically state the thickness of any photoresist which was used. However, in Figure 6 it is readily apparent that the photoresist thickness was in excess of 10000 Å, so a problem of the kind which was described by applicants probably did not exist with respect to the examples in the Okamoto et al.

reference. The Okamoto et al. reference describes the etching of a number of different materials, but the only description of the etching of silicon nitride that applicants' attorney found is at Col. 6, lines 13 - 67, continuing at Col. 7, lines 1 - 60. In this description the photoresist thickness was as described above, and the plasma source gas mixture was C_4F_8 and O_2, although there is some mention of N_2 gas in a manner where the meaning is not clear. This is in contrast with applicants' claimed invention which requires the use of a plasma source gas consisting of an inorganic fluorine compound in combination with sulfur dioxide or this combination further combined with an inert diluent gas selected from the group consisting of Ar, Kr, Xe, and He.

The Nozaki et al. reference relates to a photoresist composition that can use short wavelength light, such as that from an excimer laser for the imaging radiation. This reference describes specific chemical compositions which can be used to form the photoresist. The reference describes the use of imaging wavelengths which would be considered to be DUV. However, applicants' attorney found no mention of the etching of a silicon nitride film in this reference.

Applicants' Claims 1 - 14 pertain to a method of improving etch selectivity of silicon nitride relative to an adjacent patterned organic DUV photoresist, during plasma etching of the silicon nitride. The method comprises: reacting a surface of the patterned organic DUV photoresist with plasma species generated from a plasma source gas consisting essentially of at least one inorganic fluorine-comprising gas and sulfur dioxide (SO_2). The molecular ratio of the inorganic fluorine-comprising gas to the sulfur dioxide gas ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface, whereby the etch rate of the organic DUV photoresist is slowed, while the silicon nitride exposed through the patterned organic DUV photoresist is etched. Claims 15 - 28 pertain to a particular embodiment of applicants' invention where the plasma source gas consists essentially of at least one inorganic fluorine-comprising gas, sulfur dioxide (SO_2), and a diluent gas selected from the group consisting of Ar, Kr, Xe, and He. Claims 57 and 58 pertain to a particular embodiment of applicants' invention where the

plasma source gas consists essentially of sulfur hexafluoride (SF_6) and sulfur dioxide (SO_2). Claims 59 - 67 pertain to a particular embodiment of applicants' invention where the plasma source gas consists essentially of sulfur hexafluoride (SF_6), sulfur dioxide (SO_2), and argon (Ar).

Whether taken alone or in combination, neither the Okamoto reference nor the Nozaki reference teaches or even suggests applicants' claimed invention, as claimed in Claims 1 - 28 and 57 - 67. In light of the above distinctions, applicants respectfully request the withdrawal of the rejection of Claims 1 - 28 and 57 - 67 under 35 USC § 103(a), over Okamoto et al., in view of Nozaki et al.

Claims 29 - 56 and 68 - 87 are rejected under 35 USC § 103(a) as being unpatentable over U.S. Patent No. 6,617,257, to Ni et al. ("the Ni reference"), in view of U.S. Patent Publication No. 2002/0076935, of Maex et al. ("the Maex reference").

The Maex reference should not be cited against applicants' application under 35 USC § 103(a), since the Maex application was filed September 28, 2001 and was published June 20, 2002, while applicants' application was filed on June 13, 2001. The Maex reference is improperly cited for any purpose against applicants' invention.

Further, applicants contend that the Ni et al. reference should not be cited under 35 U.S.C. § 103 (a), since the Ni et al. application was filed on March 30, 2001 and published on December 5, 2002, while applicants' application was filed on June 13, 2001. Applicants are prepared to "swear behind the filing date" of the Ni et al. reference, if necessary.

The Ni et al. reference pertains to a method of etching an organic antireflective coating with selectivity to an underlying layer, where the etchant gas comprises a sulfur-containing gas and a carrier gas. (Col. 2, lines 1 - 10.) The organic antireflective coating can be a polymer film underlying a patterned photoresist. The etchant gas chemistry is said to be able to passivate sidewalls of openings in the photoresist to minimize the lateral etch rate of the photoresist to maintain critical dimensions defined by the photoresist. (Col. 2, lines 15 - 20). Although the

preferred sulfur-containing gas is SO_2, there is no mention of using this gas in combination with an inorganic fluorine-containing gas to improve the etch rate of silicon nitride relative to a photoresist. In fact, the organic antireflective coating is shown overlying a silicon oxide layer, so that the silicon nitride etch stop layers in the structural stack being etched are not exposed during etching of the organic antireflective coating. In fact, when the etching of silicon nitride is referenced in the Ni et al. disclosure, the etch is defined as being a separate etch from the organic antireflective coating etch, with no etch chemistry called out for the silicon nitride etch. (Please see Col. 8, lines 56-65.) There is no mention of obtaining selectivity for etching silicon nitride relative to a DUV photoresist.

The Maex reference pertains to a method for anisotropic plasma etching of organic-containing insulating layers. (Abstract) Like the Ni reference, the Maex reference pertains to etching of organic materials, not silicon nitride, as described and claimed by applicants. A combination of these two references does not render applicants' invention as claimed in Claims 29 - 56 and 68 - 87 obvious, since all of these claims pertain to the selective etching of silicon nitride relative to an organic DUV photoresist.

In more detail, Claims 29 - 40 pertain to a method of improving etch selectivity of silicon nitride relative to an adjacent patterned organic DUV photoresist during plasma etching of silicon nitride. A surface of a patterned organic DUV photoresist is reacted with plasma species generated from a plasma source gas consisting essentially of at least one inorganic fluorine-comprising gas, sulfur dioxide (SO_2), and hydrogen bromide (HBr), where the molecular ratio of the inorganic fluorine-comprising gas to the sulfur dioxide gas ranges from about 50 : 1 to about 1 : 1, to produce a reacted DUV photoresist surface. This reactive treatment slows the etch rate of the organic DUV photoresist, while the silicon nitride exposed through the patterned organic DUV photoresist is etched. Claims 41 - 56 pertain to a particular embodiment of applicants' invention where the plasma source gas consists essentially of at least one inorganic fluorine-comprising gas, sulfur dioxide (SO_2), hydrogen bromide (HBr), and a diluent gas selected from

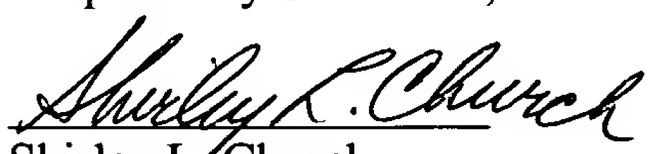
the group consisting of Ar, Kr, Xe, and He. Claims 68 - 75 pertain to a particular embodiment of applicants' invention where the plasma source gas consists essentially of sulfur hexafluoride (SF_6), sulfur dioxide (SO_2), and hydrogen bromide (HBr). Claims 76 - 87 pertain to a particular embodiment of applicants' invention where the plasma source gas consists essentially of sulfur hexafluoride (SF_6), sulfur dioxide (SO_2), hydrogen bromide (HBr), and a diluent gas selected from the group consisting of Ar, Kr, Xe, and He.

Even if the Maex reference could be cited against applicants' invention, neither the Ni reference nor the Maex reference teaches or even suggests applicants' claimed invention, as claimed in Claims 29 - 56 and 68 - 87. In light of the above distinctions, applicants respectfully request the withdrawal of the rejection of Claims 29 - 56 and 68 - 87 under 35 USC § 103(a), over Ni et al., in view of Maex et al.

Applicants contend that the presently pending claims as amended are in condition for allowance, and the Examiner is respectfully requested to enter the present amendments and to pass the application to allowance.

The Examiner is invited to contact applicants' attorney with any questions or suggestions, at the telephone number provided below.

Respectfully Submitted,



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